US-PAT-NO: 6144768

DOCUMENT-IDENTIFIER: US 6144768 A
See image for Certificate of Correction

TITLE: Method of decoding image data

DATE-ISSUED: November 7, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Mahant-Shetti; Shivaling S.	Garland	TX	N/A	N/A
Kim; Whoi Yul	Seoul	N/A	N/A	KR

US-CL-CURRENT: 382/233, 382/232 , 382/248 , 382/251

ABSTRACT:

An image encoding/decoding system (10) includes an encoder section (12) and a decoder section (14). The encoder section (12) includes an image detector (15), a transform processor (16), a quantizer (18), a zig-zag process memory (20), and a run/variable length encoder (22). The decoder section includes a variable/run length decoder (24), a dequantizer (26), a zig-zag deprocess memory (28), and an inverse transform processor (30). The inverse transform processor (30) within the decoder section (14) uses basis functions (58) based on a discrete articulated trapezoid transform for

ease of realizability in decoding image data. The discrete articulated trapezoid transform may also be used by the transform processor (16) within the encoder section (12) for the encoding of detected images.

13 Claims, 4 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 2

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Detailed Description Text - DETX (9):

In order to further **reduce error,** modifications can be done to the third order **coefficients** of the inverse discrete articulated trapezoid **transform**. When using first order discrete articulated trapezoid transform basis functions, errors occur in the third order discrete cosine transform basis functions. Modifying the **coefficients** of the third order inverse discrete articulated trapezoid **transform will reduce these errors** and provide better overall results.

Claims Text - CLTX (11):

modifying third order **coefficients** of the inverse discrete articulated trapezoid **transform to reduce error**.

Claims Text - CLTX (21):

9. The image decoder of claim 8, wherein the third order **coefficients** of the inverse discrete articulated trapezoid **transform** are modified to **reduce** **error**.

Patent Assignment Abstract of Title

Total Assignments: 1

Application #: 09694455 **Filing Dt:** 10/23/2000 **Patent #:** NONE **Issue Dt:**

PCT #: NONE **Publication #:** NONE **Pub Dt:**

Inventors: Joan LaVerne Mitchell, Jennifer Quirin Trelewicz, Michael Thomas Brady

Title: Faster transforms using early aborts and precision refinements

Assignment: 1

Reel/Frame: 011268/0776 **Received:** 11/28/2000 **Recorded:** 10/23/2000 **Mailed:** 01/29/2001 **Pages:** 2

Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).

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Web interface last modified: Oct. 5, 2002

US-PAT-NO: 5822003

DOCUMENT-IDENTIFIER: US 5822003 A

TITLE: Method and apparatus for performing fast reduced coefficient discrete cosine transforms

DATE-ISSUED: October 13, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Girod; Bernd	91080 Spardorf	N/A	N/A	DE
Ericsson; Staffan	Brookline	MA	02146	N/A

US-CL-CURRENT: 375/240.12, 375/240.2 , 382/236 , 382/238 , 382/239 , 382/250

ABSTRACT:

A method is provided for performing a fast 3-coefficient Discrete Cosine Transform (DCT) in a software implementation. The method provided exploits symmetries and statistical properties of the coefficients found in the DCT. As a result of the symmetries and statistical distribution of coefficients typically found in the DCT of typical images in image processing applications, the 3-coefficient DCT may be readily performed using as few as three input sample values from an input image block. The method selects the samples from

locations in the image block where they are at peaks of the basis functions for the coefficients included, thus maximizing noise immunity. The method also provides for switching between performing the 3-coefficient DCT and a full (or other) DCT as required by image quality. Finally, the method may be generalized to perform a reduced coefficient DCT of any number of coefficients less than all coefficients in a complete output block.

7 Claims, 7 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 5

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Brief Summary Text - BSTX (19):

There is provided, according to yet another aspect of the present invention, yet another method of performing in a computer executing a sequence of instructions, a discrete cosine transform on an input block of N.times.N image samples, each image sample represented by a sample value. The method according to this aspect of the invention comprises the steps of: performing in the computer a **reduced coefficient** discrete cosine transformation on the input block to form L of N.times.N first **coefficients**; filling the N.times.N-L first **coefficients** not formed with a value of zero; performing in the computer an

inverse discrete cosine transformation on the formed first **coefficients** to form a reconstructed block; comparing the input block with the reconstructed block; and if an **error** value obtained by comparing the reconstructed block with the input block is not less than a predetermined **threshold,** performing in the computer an N.times.N **coefficient** discrete cosine **transform** on the input block to form second **coefficients**; and if the second **coefficients** are formed, outputting the second **coefficients,** but otherwise outputting the first **coefficients**.

US-PAT-NO: 5412741

DOCUMENT-IDENTIFIER: US 5412741 A

TITLE: Apparatus and method for compressing information

DATE-ISSUED: May 2, 1995

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Shapiro; Jerome M.	Philadelphia	PA	N/A	N/A

US-CL-CURRENT: 382/232, 358/1.9 , 375/240.11

ABSTRACT:

An apparatus and method for signal, image, or video compression that achieves high compression efficiency in a computationally efficient manner and corresponding decoder apparatus and methods are disclosed. This technique uses zerotree coding of wavelet coefficients in a much more efficient manner than previous techniques. The key is the dynamic generation of the list of coefficient indices to be scanned, whereby the dynamically generated list only contains coefficient indices for which a symbol must be encoded. This is a dramatic improvement over the prior art in which a static list of coefficient indices is used and each coefficient must be individually checked to see whether a) a symbol must be encoded, or b) it is

completely predictable.
Additionally, using dynamic list generation, the greater the compression of the signal, the less time it takes to perform the compression. Thus, using dynamic list generation, the computational burden is proportional to the size of the output compressed bit stream instead of being proportional to the size of the input signal or image.

21 Claims, 11 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 10

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Brief Summary Text - BSTX (11):
Apparatus for encoding information comprises filter means for forming a wavelet **transform** of the image, means for forming a zerotree map from the output of the filter means, means for setting an initial threshold for encoding the wavelet **coefficients**, means for encoding the significant **coefficients** on an initial dominant list from the coarsest level of the **transform** and the children of those **coefficients** whose indices are appended to the dominant list as the **coefficient** of the parent is found to be significant, means for reducing the threshold, means for **refining** the estimate of the value of the significant **coefficients** to increase the accuracy of the coded **coefficients**, and means for

cycling back to means for encoding the significant **coefficients** to scan the dominant list anew at the new, reduced threshold.

Brief Summary Text - BSTX (12):

The invention is a method for encoding information comprising the steps of forming a wavelet **transform** of the image, forming a zerotree map of the wavelet **coefficients**, setting an initial threshold for encoding the wavelet **coefficients**, encoding the significant **coefficients** on an initial dominant list from the coarsest level of the **transform** and the children of those **coefficients** whose indices are appended to the dominant list as the **coefficient** of the parent is found to be significant, reducing the threshold, **refining** the estimate of the value of the significant **coefficients** to increase the accuracy of the coded **coefficients**, and cycling back to scan the dominant list anew at the new, reduced threshold.

US-PAT-NO: 5787204

DOCUMENT-IDENTIFIER: US 5787204 A

TITLE: Image signal decoding device capable of removing block distortion with simple structure

DATE-ISSUED: July 28, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Fukuda; Hiroyuki	Tokyo	N/A	N/A	JP

US-CL-CURRENT: 382/233, 382/250 , 382/251

ABSTRACT:

An image signal decoding device divides image data into blocks and performs orthogonal transform on image data of each of block to thereby decode coded image data. An inverse orthogonal transform circuit performs inverse orthogonal transform on the coded image data. A detecting circuit detects the band of each of the blocks of the coded image data. A distortion removing circuit changes the distortion removal characteristics according to the band detected by the detecting circuit to remove distortion of image data subjected to the inverse orthogonal transform by the inverse orthogonal transform circuit.

2 Claims, 38 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 19

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Detailed Description Text - DETX (88):
In FIG. 18, compressed image data is read into a variable-length code decoding circuit 310. The output of the variable-length code decoding circuit is returned to orthogonal transform coefficients by an inverse quantization circuit 311. The orthogonal transform coefficients are transformed to real-space data by an inverse orthogonal transform circuit 312 and then subjected to a distortion removing process by a distortion removing circuit 313. The output of the distortion removing circuit 313 is transformed to orthogonal transform coefficients again by an orthogonal transform circuit 314. A clipping circuit 315 obtains the amount of change of each of orthogonal transform coefficients of the same block which are obtained by the orthogonal transform circuit 314 and the inverse quantization circuit 311. When the amount of change is greater than a possible maximum value of the quantization **error of each coefficient, the transform coefficients** after the distortion removing process are **corrected** such that the amount of change falls below the

possible maximum value. The corrected coefficients are transformed to real-space data again by an inverse orthogonal transform circuit 316, the real-space data being displayed on an output device as a reproduced image.

US-PAT-NO: 5534925

DOCUMENT-IDENTIFIER: US 5534925 A

TITLE: Image compression by optimal reconstruction

DATE-ISSUED: July 9, 1996

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Zhong; Sifen	Los Angeles	CA	N/A	N/A

US-CL-CURRENT: 348/384.1, 382/199

ABSTRACT:

A method of producing a video image from a compressed version of a source video image which has been compressed by transforming to a transform domain and quantizing the source video image in accordance with quantization constraints, including back-transforming from the transform domain and dequantizing the compressed version to produce a decompressed video image, reducing total variation in the first decompressed video image to produce a reduced variation image, transforming the reduced variation image to produce a revised transform and conforming the revised transform with the quantization constraints of the compressed version so as to produce a constrained transform, and back-transforming the constrained transform so as

to produce a replica of the
source video image.

24 Claims, 14 Drawing figures

Exemplary Claim Number: 6

Number of Drawing Sheets: 8

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Detailed Description Text - DETX (50):
The four quantized transforms F.sub.0, E.sup.1.sub.L, E.sup.2.sub.H and E.sup.3.sub.U are transmitted as the compressed image data representing the source image f. The advantage is that this process produces much smaller residuals which can be encoded in fewer bits. The quantized D.C. **transform coefficient** F.sub.0 is of significantly greater magnitude than the **transform** residuals E.sup.1.sub.L, E.sup.2.sub.H and E.sup.3.sub.U and contains most of the information required for production of a replica u of the source image f. The magnitudes of the successive **refinements** represented by E.sup.1.sub.L, E.sup.2.sub.H and E.sup.3.sub.U fall off significantly, and therefore require less data to represent them. Where conventional thresholding and minimum redundancy encoding are used, the higher order refinements may be zero over many frames, thereby greatly increasing data compression.

Detailed Description Text - DETX (55):

The optimal prediction feature of the present invention is employed in one embodiment to expand an image to a large number of pixels (e.g., 16 times as many pixels). Referring to FIG. 13, the value of each pixel in the initial smaller image u.sub.0 is assigned to the zero frequency or D.C. transform coefficient of a corresponding 4-by-4 block of transform coefficients in which the remaining coefficients are of zero magnitude, all of the 4-by-4 blocks constituting a spatial frequency transform F.sub.0. A reconstruction processor illustrated in FIG. 14 of the type described above is employed to generate the expanded image from F.sub.0. In FIG. 14, a dequantization processor 600 dequantizes each **coefficient** in F.sub.0 and an inverse **transform** processor 610 **transforms** all 4-by-4 blocks of dequantized **transform coefficients** to produce a spatial domain image u. An evolution processor 620 of the type described above reduces the total variation in u and then a projection processor 630 of the type described above **refines** u in accordance with the quantization constraints on each corresponding **transform coefficient** in F.sub.0 to produce a **refined** version of u. The **refined** version of u is fed back to the input of the evolution processor 620 in a repetitive cycle that is terminated by a decision processor 640 upon a predetermined number of iterations being completed or upon average change across the image induced by the evolution processor 620 in a given iteration of the cycle falling below a

predetermined value. At this
point, the latest version of u is output as the
optimum expanded image.

US-PAT-NO: 5534925

DOCUMENT-IDENTIFIER: US 5534925 A

TITLE: Image compression by optimal reconstruction

DATE-ISSUED: July 9, 1996

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Zhong; Sifen	Los Angeles	CA	N/A	N/A

US-CL-CURRENT: 348/384.1, 382/199

ABSTRACT:

A method of producing a video image from a compressed version of a source video image which has been compressed by transforming to a transform domain and quantizing the source video image in accordance with quantization constraints, including back-transforming from the transform domain and dequantizing the compressed version to produce a decompressed video image, reducing total variation in the first decompressed video image to produce a reduced variation image, transforming the reduced variation image to produce a revised transform and conforming the revised transform with the quantization constraints of the compressed version so as to produce a constrained transform, and back-transforming the constrained transform so as

to produce a replica of the source video image.

24 Claims, 14 Drawing figures

Exemplary Claim Number: 6

Number of Drawing Sheets: 8

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Detailed Description Text - DETX (55):

The optimal prediction feature of the present invention is employed in one embodiment to expand an image to a large number of pixels (e.g., 16 times as many pixels). Referring to FIG. 13, the value of each pixel in the initial smaller image u.sub.0 is assigned to the zero frequency or D.C. transform coefficient of a corresponding 4-by-4 block of transform coefficients in which the remaining coefficients are of zero magnitude, all of the 4-by-4 blocks constituting a spatial frequency transform F.sub.0. A reconstruction processor illustrated in FIG. 14 of the type described above is employed to generate the expanded image from F.sub.0. In FIG. 14, a dequantization processor 600 dequantizes each **coefficient** in F.sub.0 and an inverse **transform** processor 610 **transforms** all 4-by-4 blocks of dequantized **transform coefficients** to produce a spatial domain image u. An evolution processor 620 of the type described above **reduces** the total variation in u and then a projection processor 630 of the

type described above **refines** u in accordance with the quantization constraints on each corresponding **transform coefficient** in F.sub.0 to produce a **refined** version of u. The **refined** version of u is fed back to the input of the evolution processor 620 in a repetitive cycle that is terminated by a decision processor 640 upon a predetermined number of iterations being completed or upon average change across the image induced by the evolution processor 620 in a given iteration of the cycle falling below a predetermined value. At this point, the latest version of u is output as the optimum expanded image.